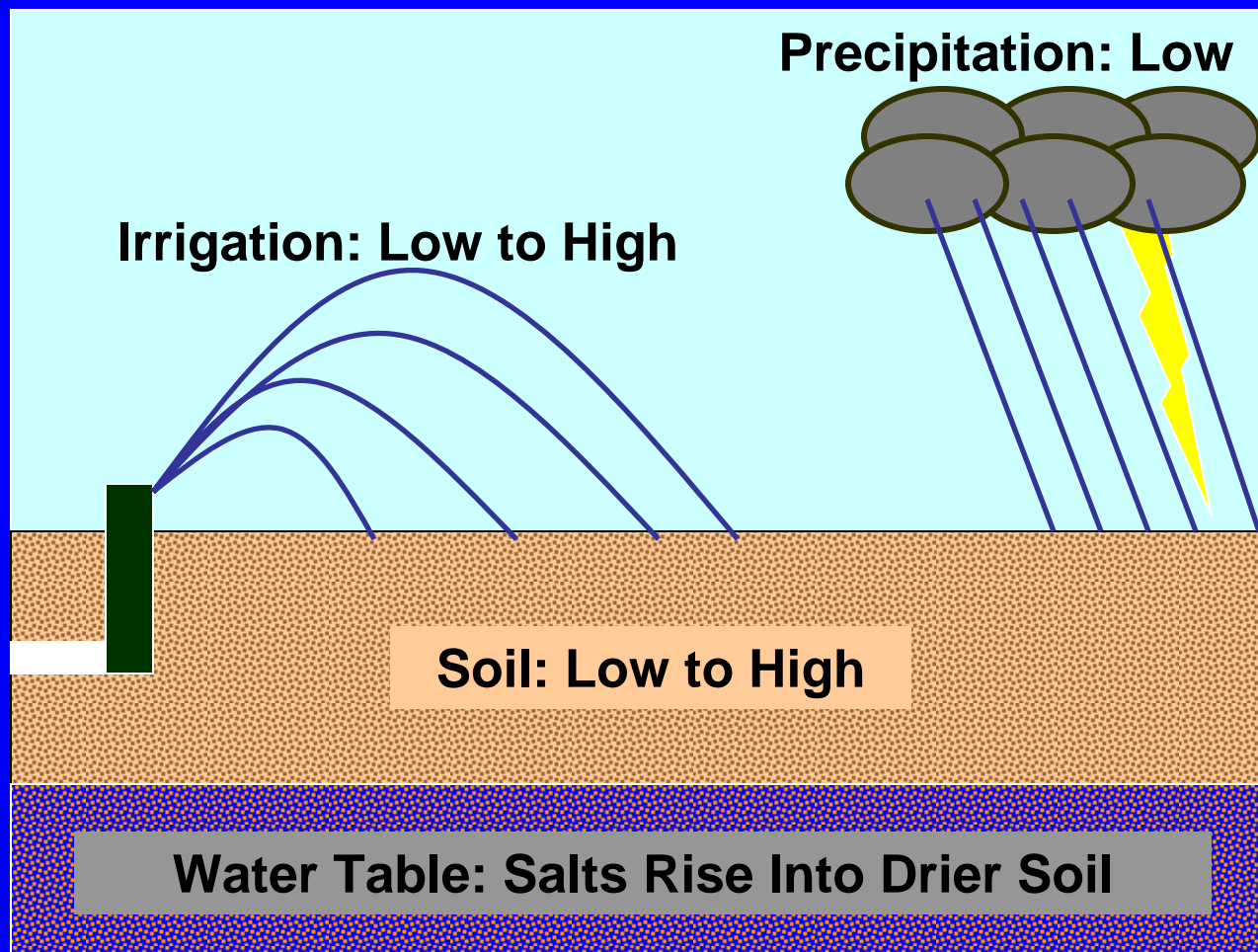


IRRIGATION WITH EFFLUENT: Will Salinity Become a Problem?

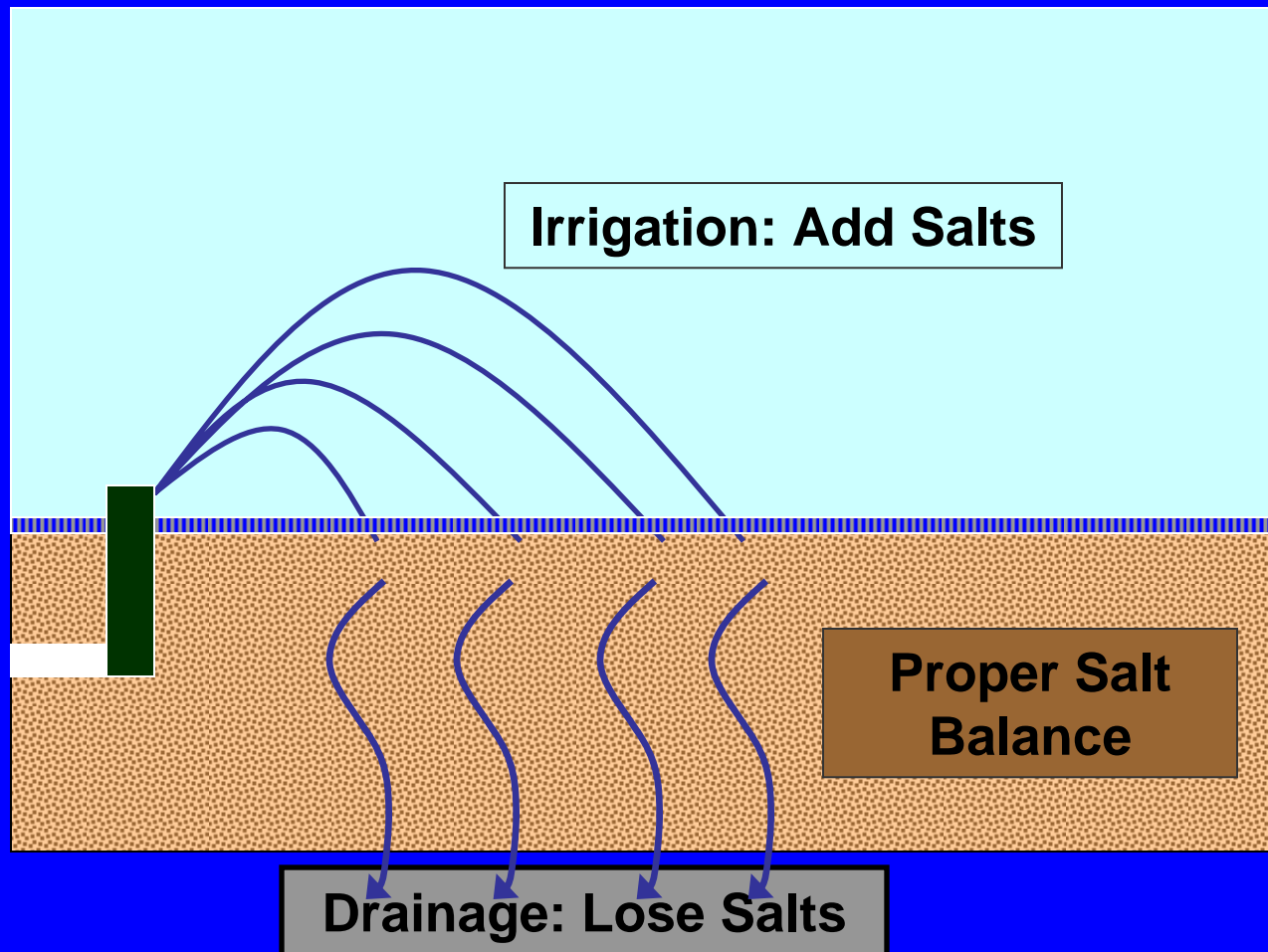
**Paul Brown
Extension Specialist, Biometeorology
University of Arizona**

Email: pbrown@ag.arizona.edu

WHERE DO SALTS COME FROM??

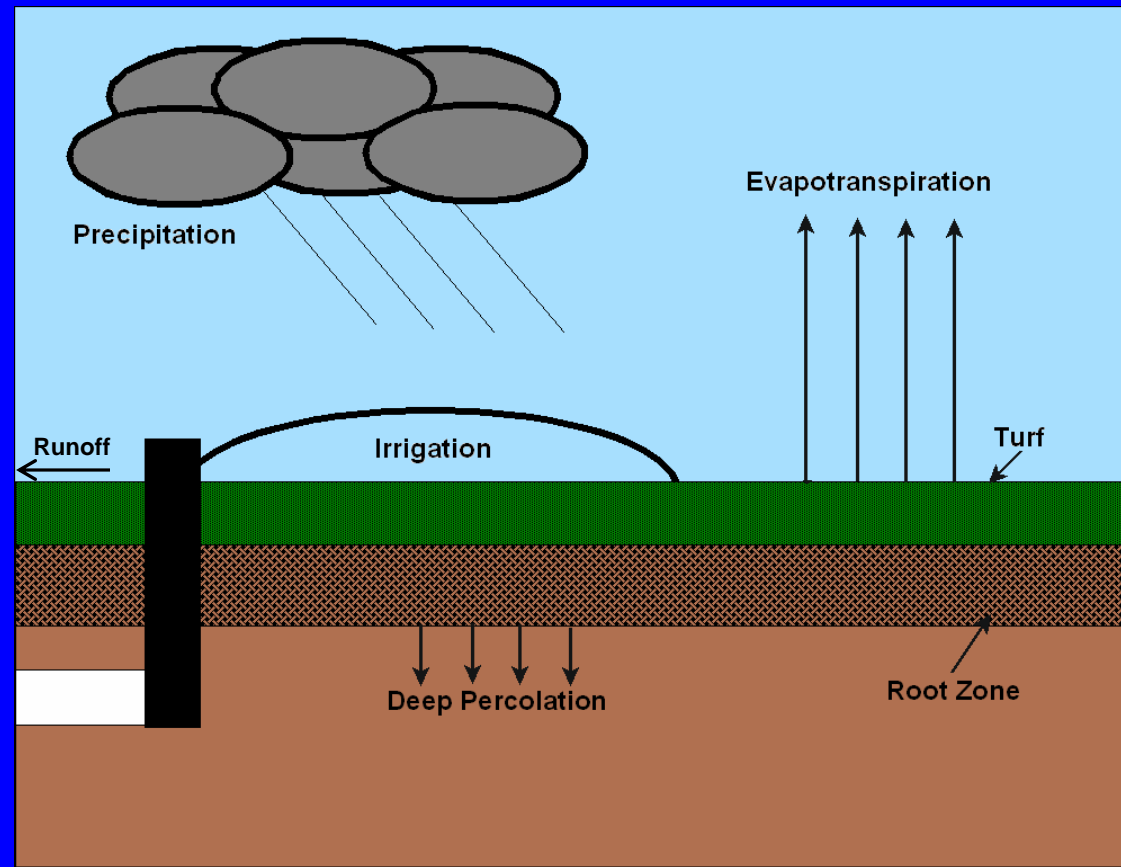


SALINITY MANAGEMENT



TURF WATER BALANCE

Linked to Salt Balance



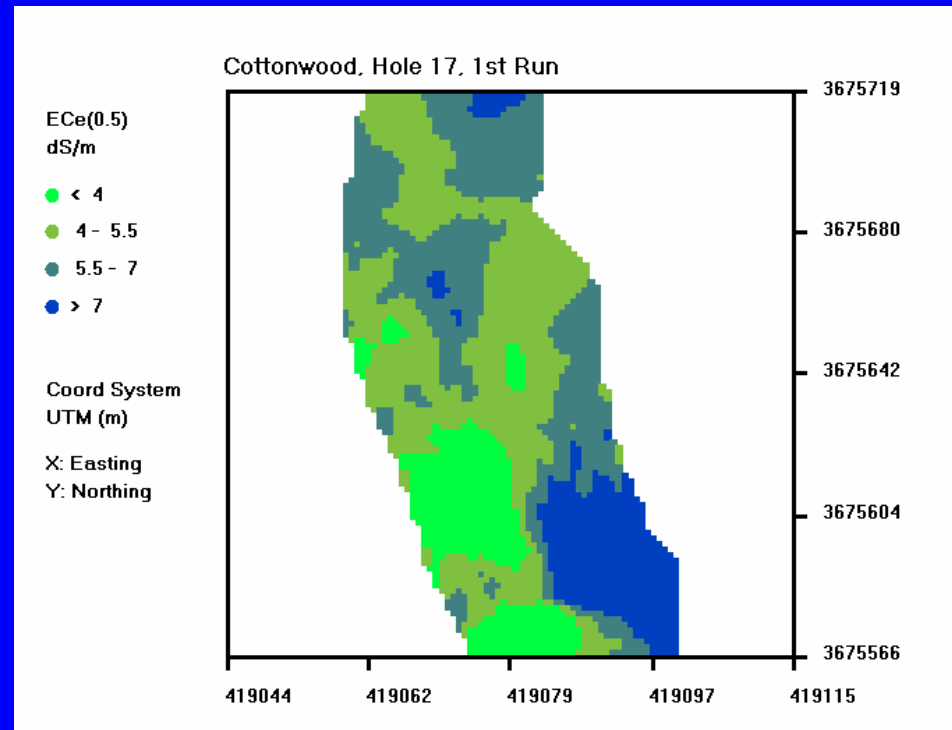
Inputs: **Irrigation** & Precipitation

Losses: Evapotranspiration, Runoff & **Drainage**

WILL SALINITY BECOME A PROBLEM?

It Already Has!!

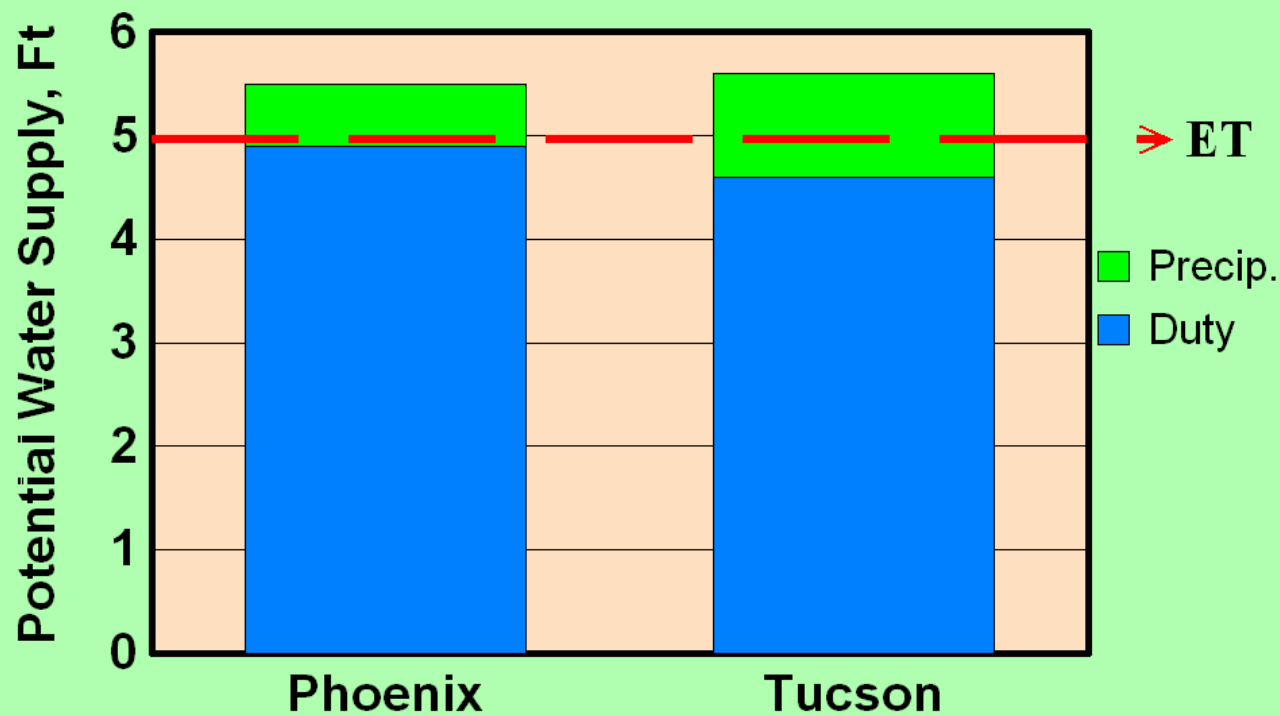
- Water Supply
 - Quantity
 - Quality
- Irrigation System
 - Non-Uniformity
 - Precipitation Rate
- Playability
- Drought



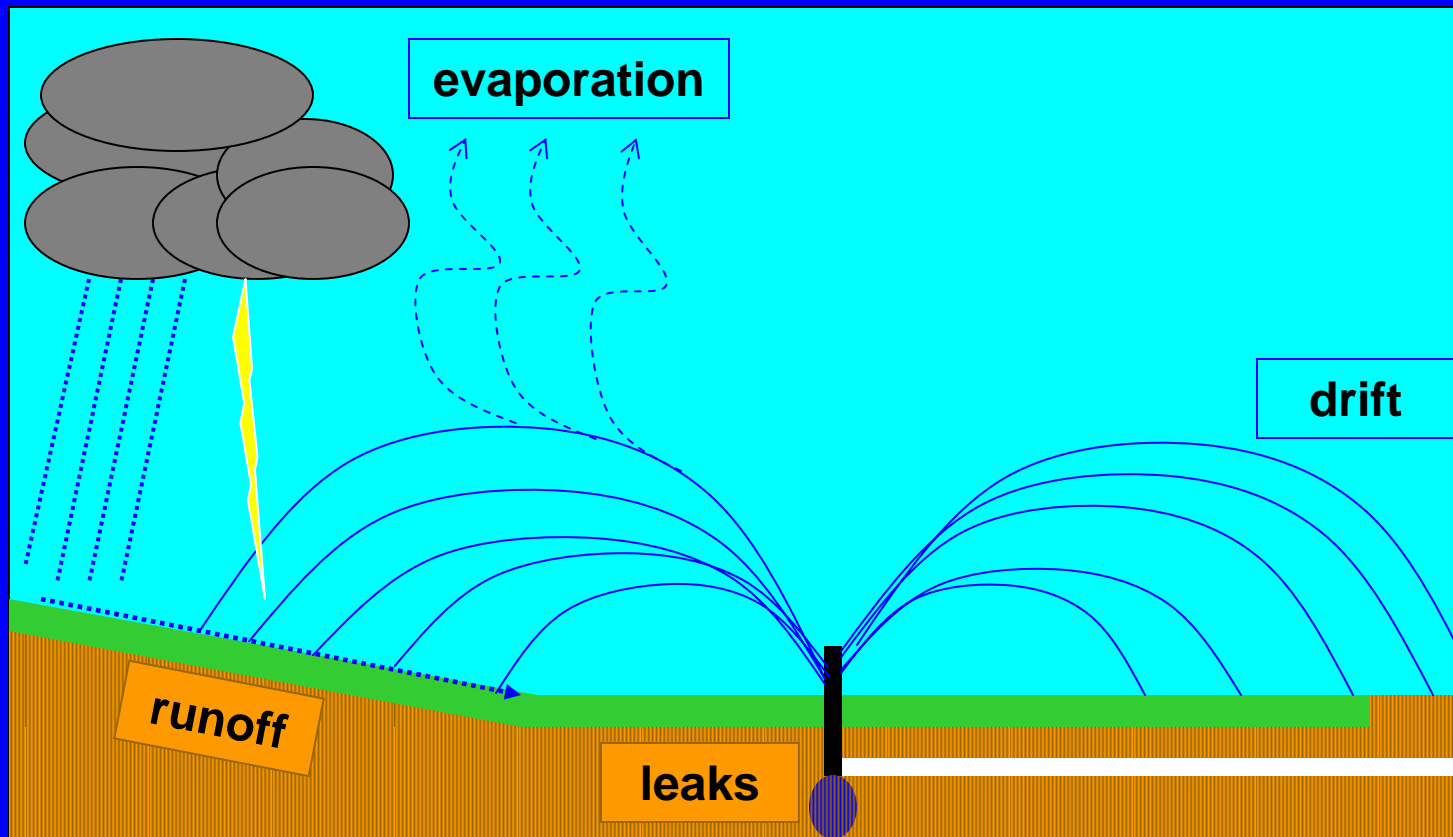
WATER SUPPLY FOR TURF

Turf Water Supply

Water Source: Groundwater



USABLE WATER SUPPLY IS ALWAYS LESS THAN POTENTIAL



EVALUATION OF ADWR WATER DUTIES FOR LARGE TURF FACILITIES

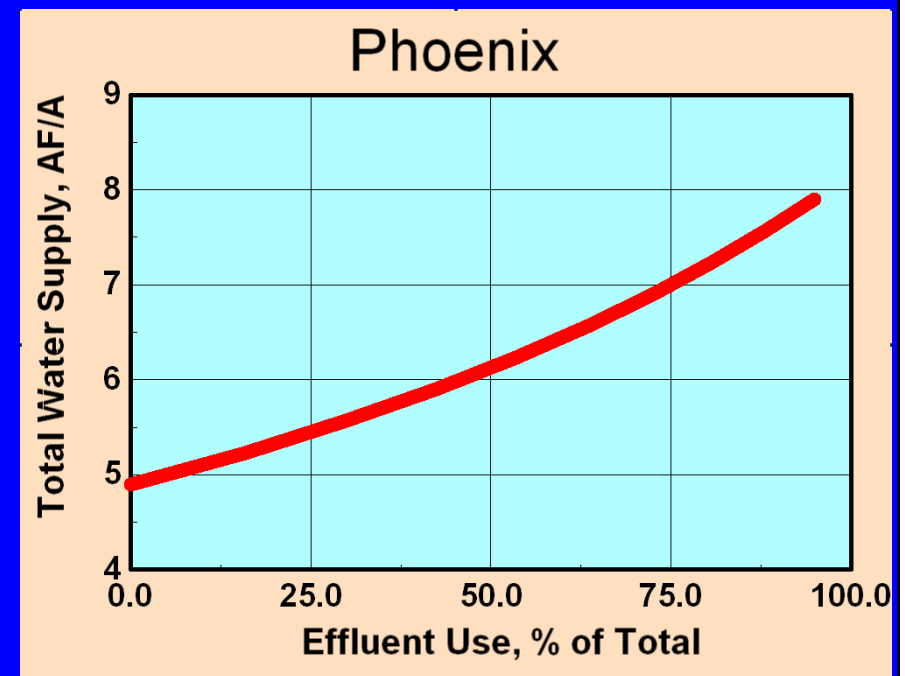
% of Duty Infiltrating Soil	% of Precipitation Lost to Runoff (Normal Year)											
	0		10		20		30		40		50	
	In	mm	In	mm	In	mm	In	mm	In	mm	In	mm
100	8.6	219.5	7.9	200.6	7.2	181.7	6.4	162.8	5.7	143.9	4.9	125.0
95	5.7	144.8	5.0	125.9	4.2	107.0	3.5	88.1	2.7	69.2	2.0	50.3
90	2.8	70.1	2.0	51.2	1.3	32.3	0.5	13.4	-0.2	-5.5	-1.0	-24.4
85	-0.2	-4.6	-0.9	-23.5	-1.7	-42.4	-2.4	-61.3	-3.2	-80.2	-3.9	-99.1
80	-3.1	-79.2	-3.9	-98.1	-4.6	-117.0	-5.4	-135.9	-6.1	-154.8	-6.8	-173.7
75	-6.1	-153.9	-6.8	-172.8	-7.5	-191.7	-8.3	-210.6	-9.0	-229.5	-9.8	-248.4

Blue Text: Surplus Water for Leaching/Conservation

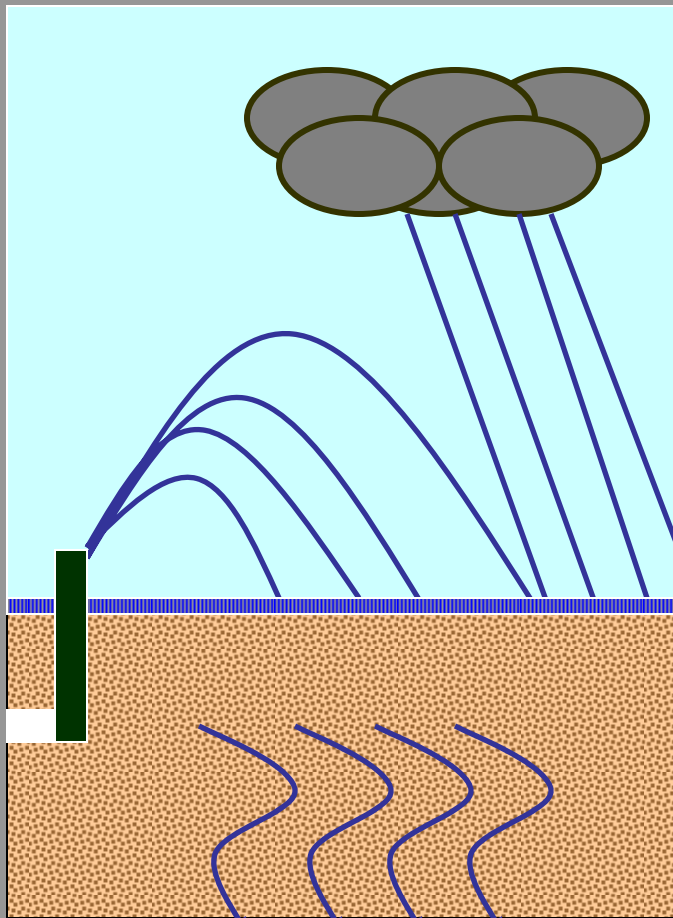
Red Text: Deficit Water Situation

EFFLUENT & WATER SUPPLY

- **Blended With Groundwater**
 - **Each Acre-Foot Counts As...**
 - 0.6 Acre-Feet in Phoenix
 - 0.7 Acre-Feet in Tucson
- **100% Effluent**
 - **Not Regulated By DWR**
 - **Local Supply Restrictions?**
 - **Cost?**
- **Water Quality**
 - **Higher Salinity & Sodium**
 - **Additional Leaching**

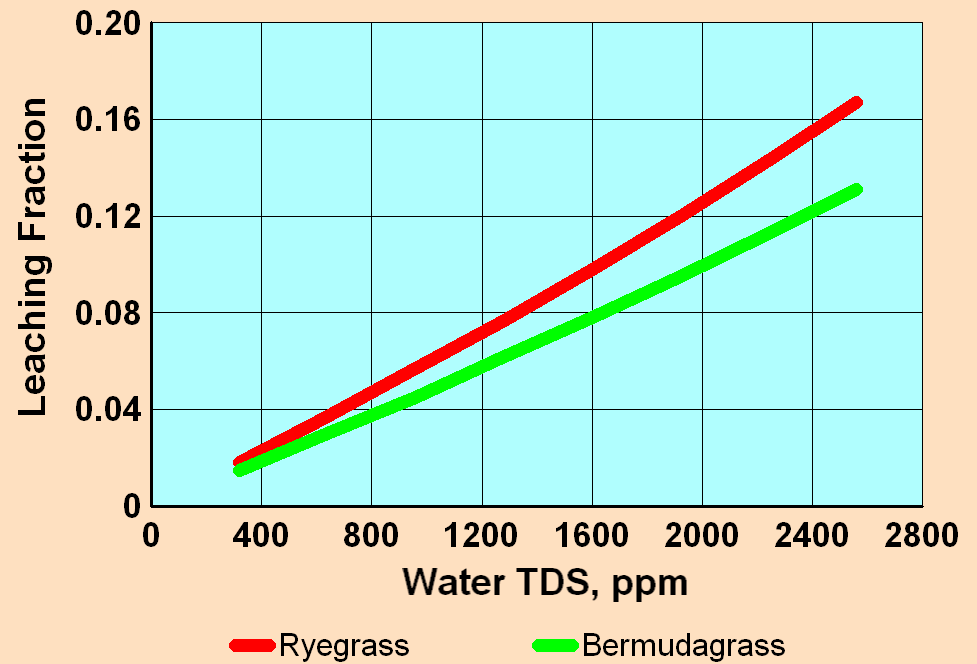


EFFLUENTS WILL REQUIRE MORE LEACHING



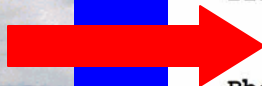
Salts

Leaching Fraction vs. Salinity of Water



Varies With Species & Water Quality

TURF WATER USE (ET)



Phoenix Area Turf Water Use Report

APR, 10 2007

Turf: Bermuda

LOCATION	----- Water Use In Inches For Previous -----					
	Day		3 Days		7 Days	
	AC	HQ	AC	HQ	AC	HQ
Phoenix Greenway	.16	.18	.45	.51	.99	1.13
Phoenix Encanto	.17	.19	.46	.52	.99	1.12
Desert Ridge	.17	.19	.47	.54	1.09	1.24
Mesa	.16	.18	.48	.55	1.10	1.25
Buckeye	.15	.17	.46	.53	1.08	1.23
Queen Creek	.18	.21	.54	.61	1.22	1.39
AREA AVERAGE	.16	.19	.48	.54	1.08	1.23

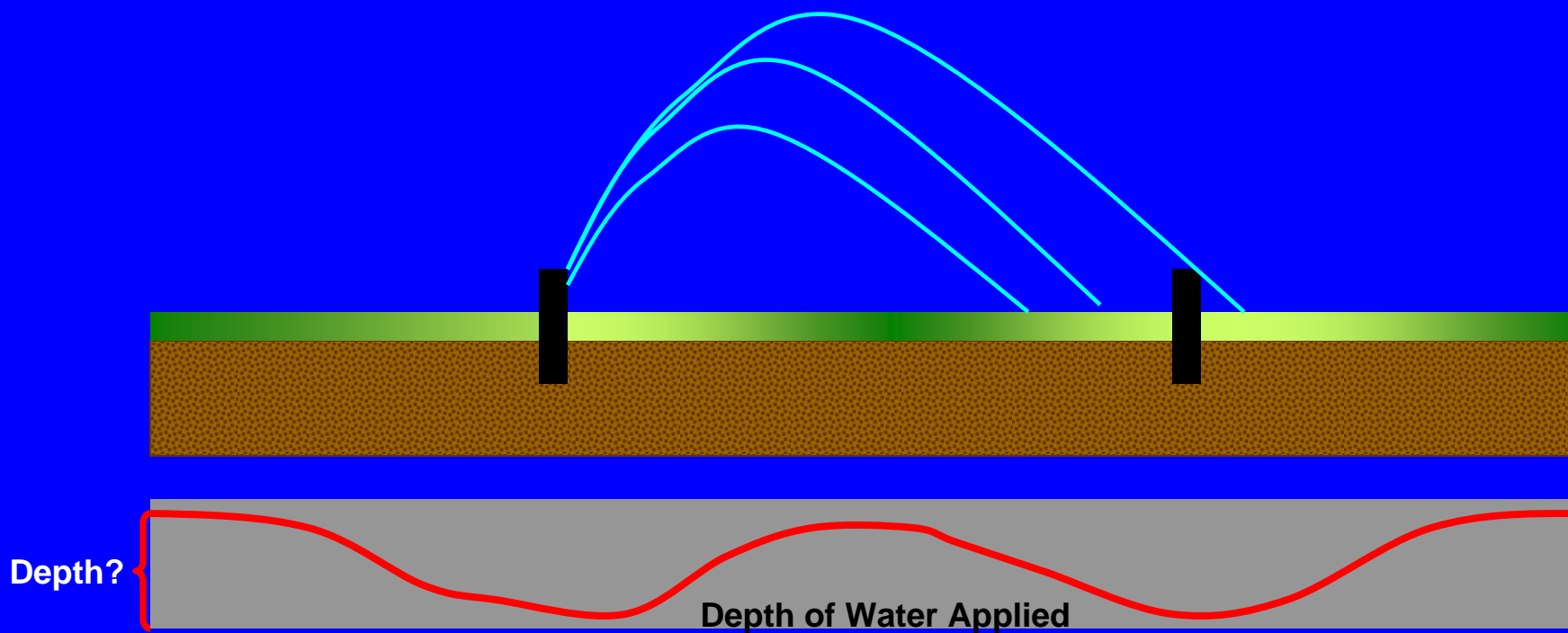
AC: Acceptable Quality Turf

HQ: High Quality Turf

IRRIGATION SYSTEM PERFORMANCE

Perhaps More Important Than Water Supply!!!

Do We Know Precipitation Rate & Uniformity??

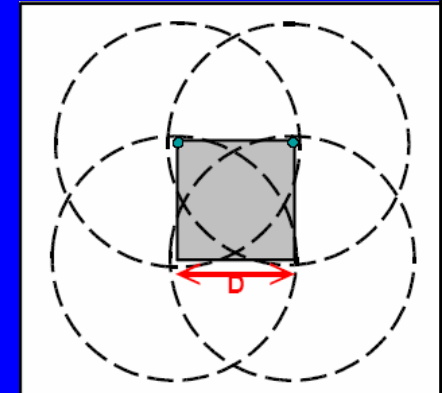


PRECIPITATION FORMULAS

For Square Spacing of Heads:

$$PR = (GPM * 96.3)/D^2$$

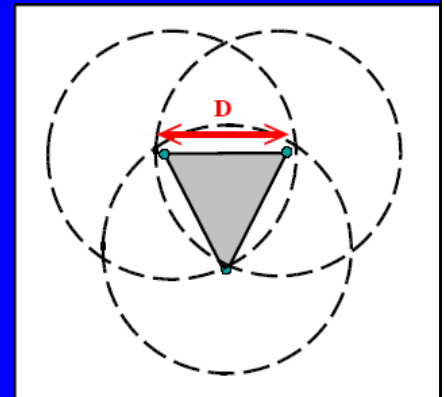
Where: PR is the precipitation rate in inches/hour
GPM is Discharge of full circle head in gallons per minute.
D is the spacing distance between adjacent heads in feet.



For Triangular Spacing of Heads:

$$PR = (GPM * 96.3)/[D^2 * 0.866]$$

Where: PR is the precipitation rate in inches/hour
GPM is Discharge of full circle head in gallons per minute.
D is the spacing distance between adjacent heads in feet.



Need Discharge Rate of Head & Distance Between Heads

MEASURING PRECIPITATION RATE

Important Aspect of the Irrigation Audit

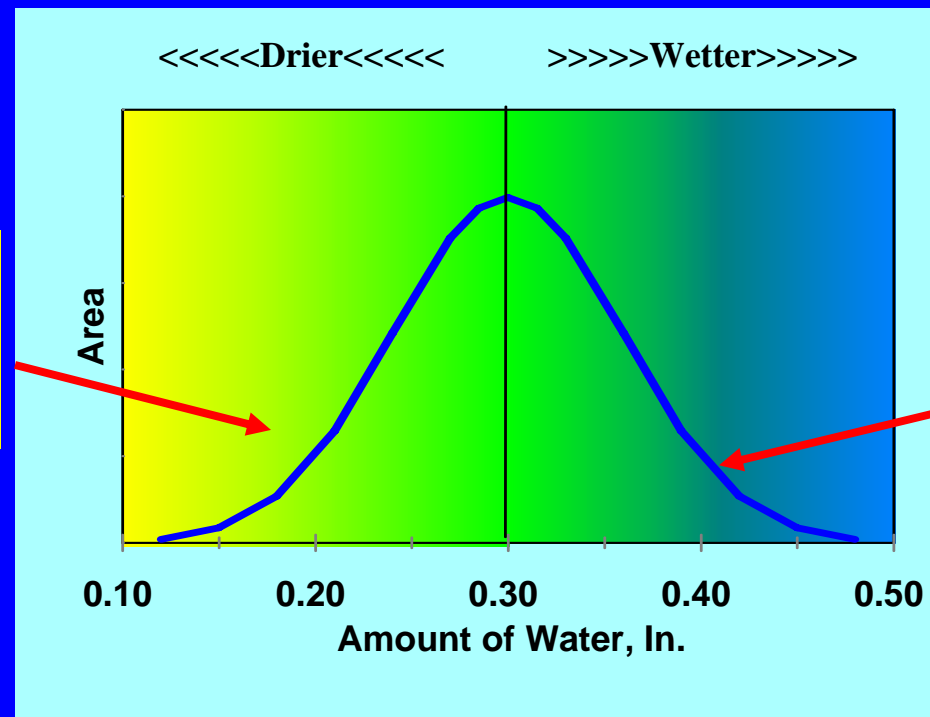


Catch Can



Catch Cans on Fairway

IRRIGATION NON-UNIFORMITY



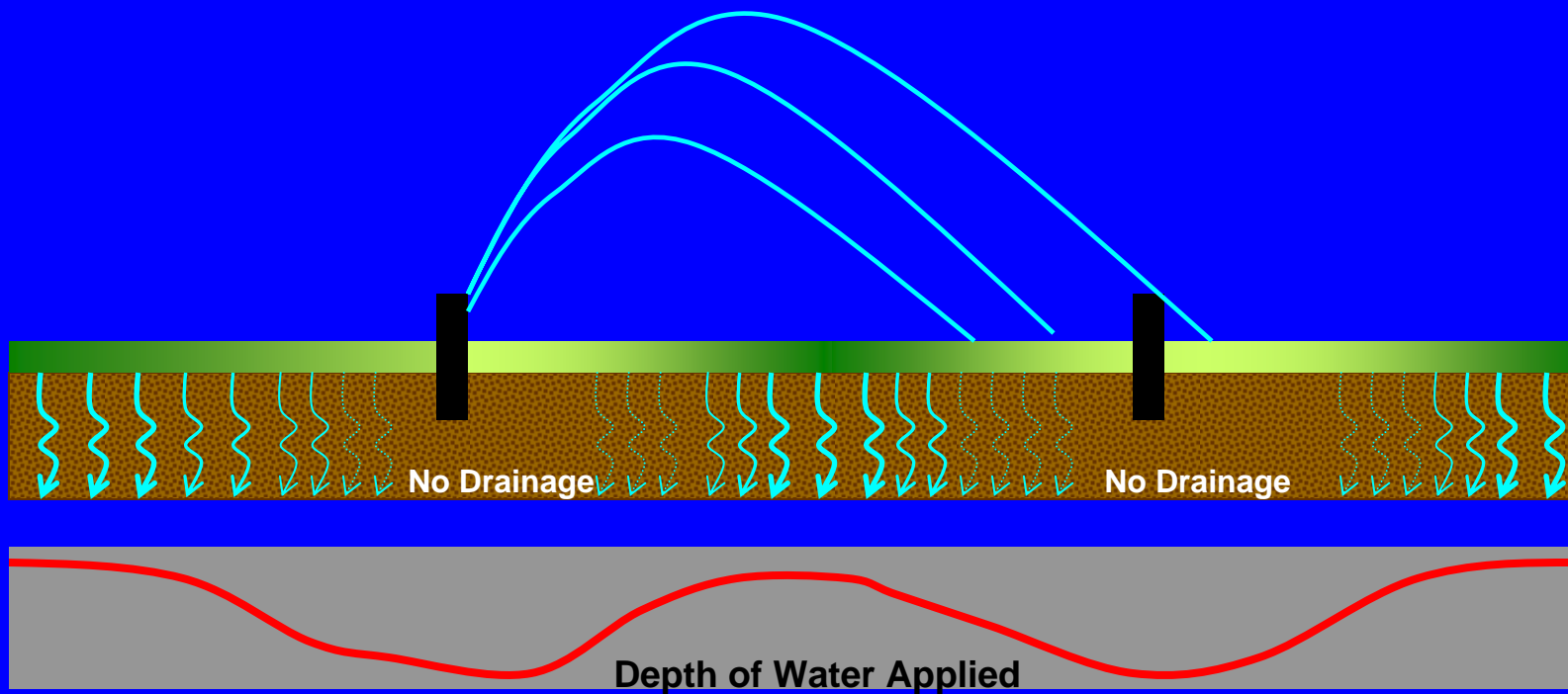
**Brown Spots
No Leaching**

**Wet Spots
Runoff
Leaching**

If you apply 0.30", some areas will receive more than 0.40" and others less than 0.20".

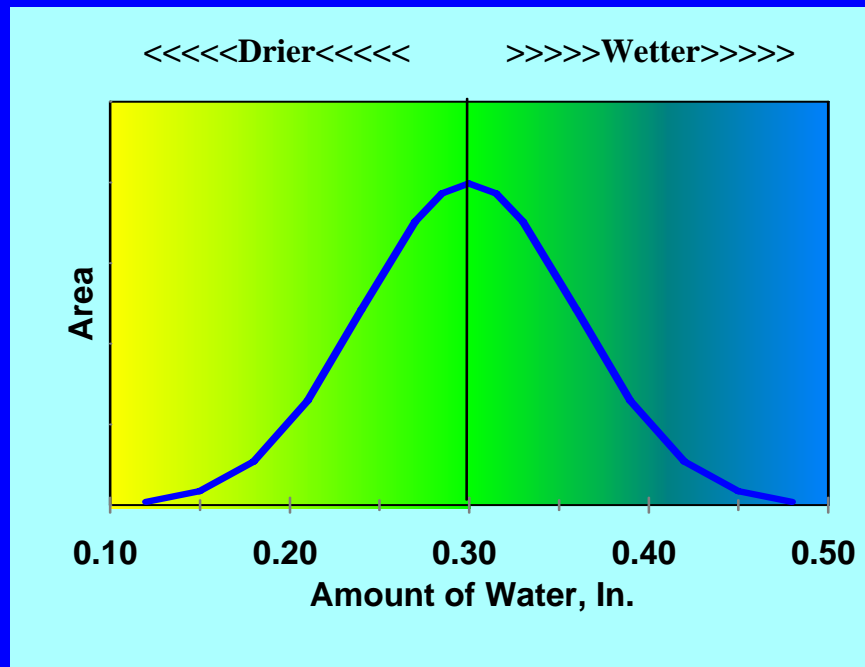
IRRIGATION NON-UNIFORMITY

If Water is Applied At Rate of ET, You Will Have Areas With Deficit & Excessive Irrigation!!!

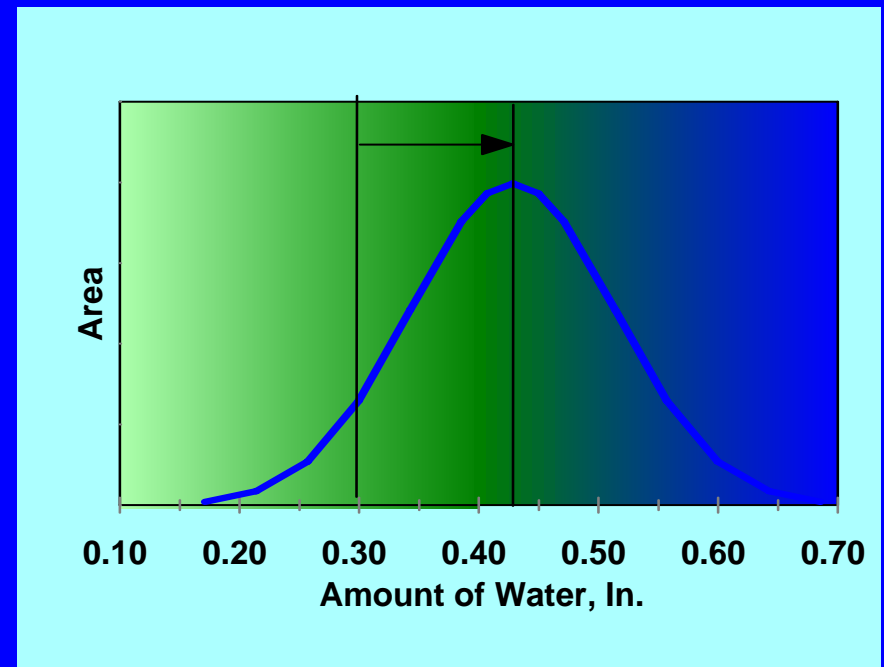


RUN TIME MULTIPLIERS

Run Entire System Extra Time to Wet Dry Areas



Original Application of 0.30"

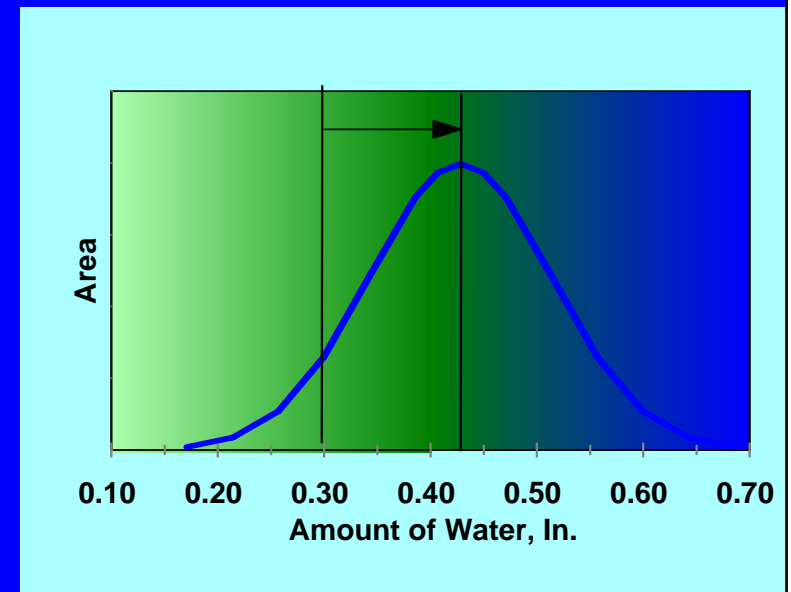


Run System Extra Time to Eliminate Dry Spots

RUN TIME MULTIPLIERS

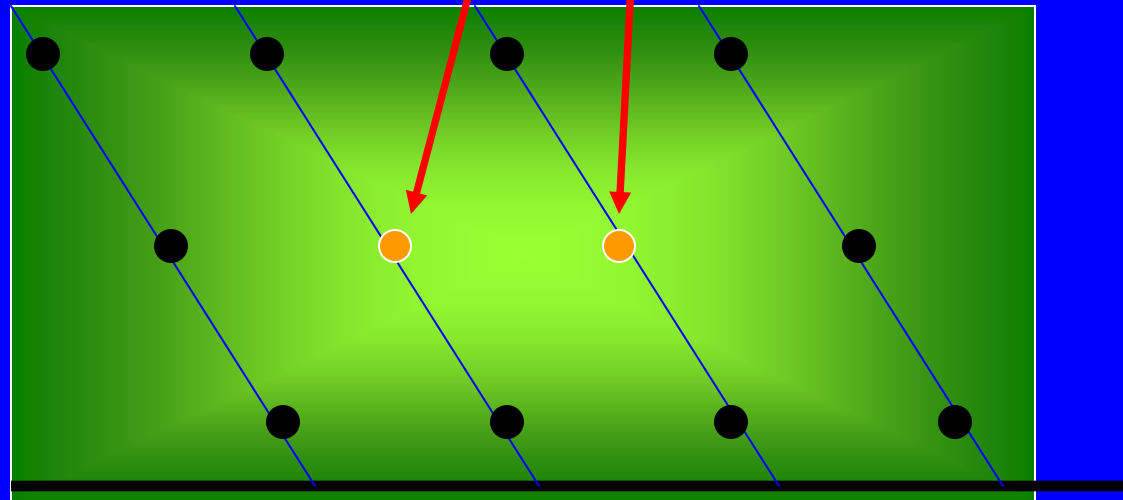
Facilitate Leaching But...

- **Playability**
 - Golf Courses & Playing Fields Too Wet
- **System Capacity**
 - Apply 20-40% More Water in Window???
- **Regulatory Limitations**
 - CU = 4.9' Already
 - Multipliers Require 6-7+ Feet of Water
- **Valve-In-Head Design**
 - Run Individual Heads In Dry Areas



VALVE IN HEAD DESIGN

Run Only These Heads

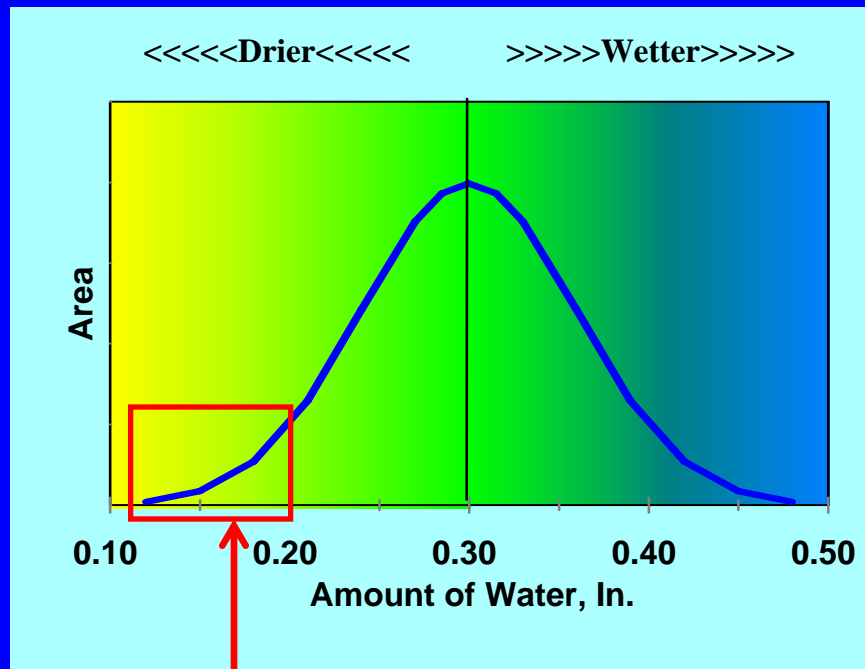


Run Head In Dry Areas Only!!

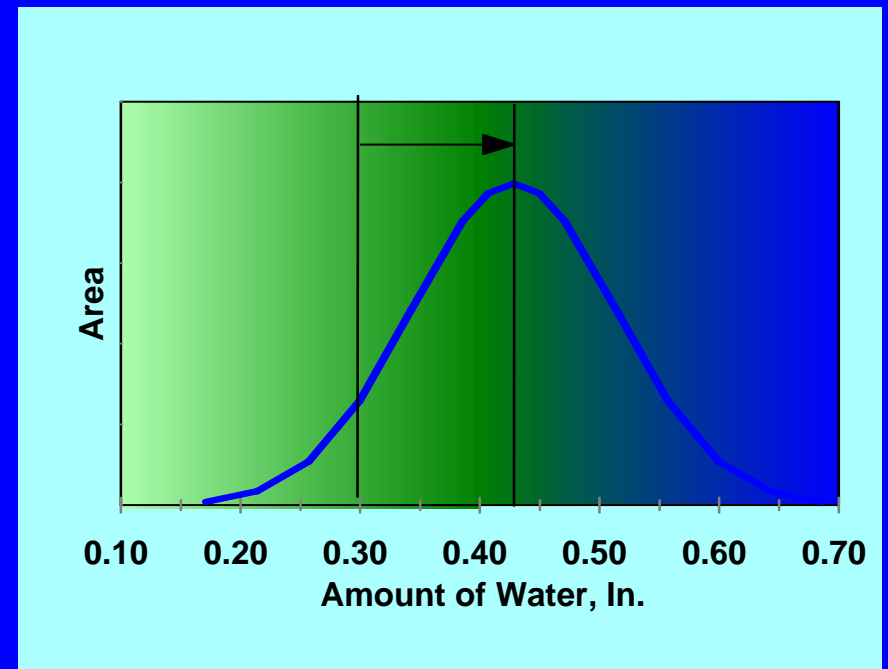
RUN TIME MULTIPLIERS

An Obsolete Concept???

To Eliminate Areas Receiving $<0.20''$...

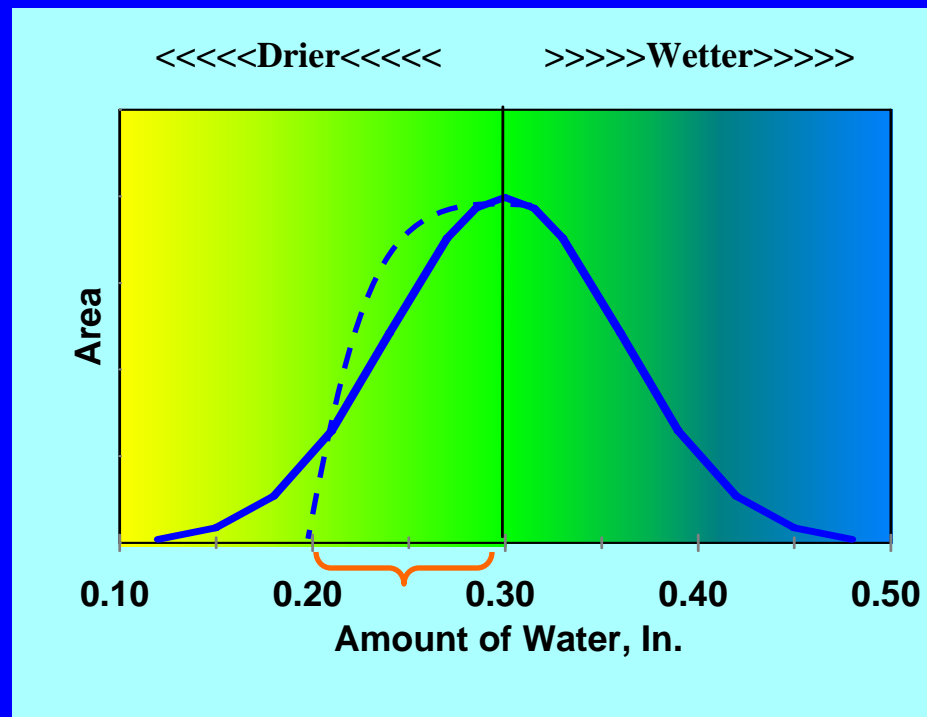


Running Specific Heads or Pulling Hoses Increases Water Applied By 5%



Running Entire System Increases Water Applied By 43% & Produces Excessive Wetness

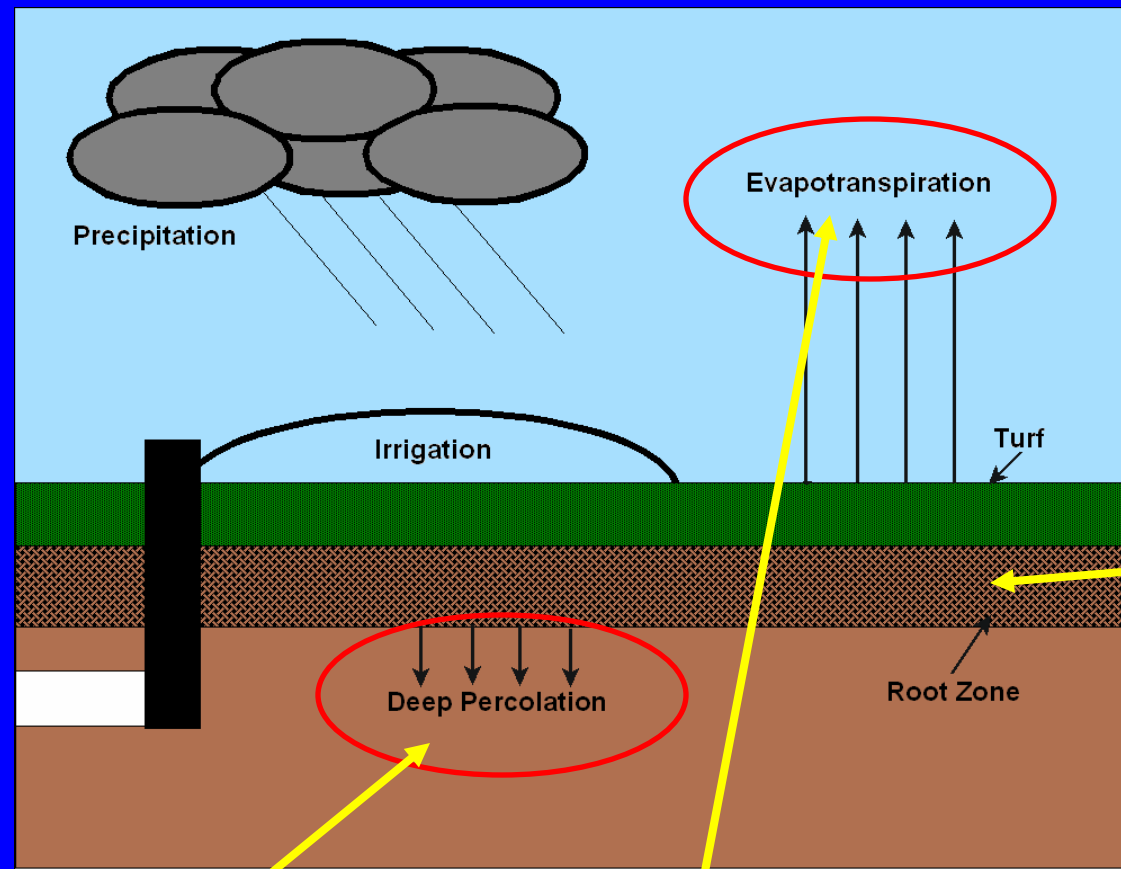
PLAYABILITY DICTATES MINIMIZING WET SPOTS!!



**Likely Results in Significant Areas of Deficit Irrigation
Where Leaching is Insufficient or Non-Existent.**

DEFICIT IRRIGATION

Water Applied Insufficient to Meet Evaporative Demand & Drainage Requirements



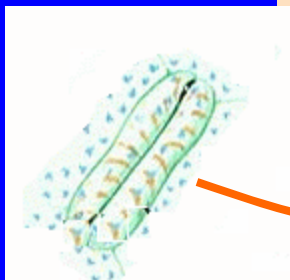
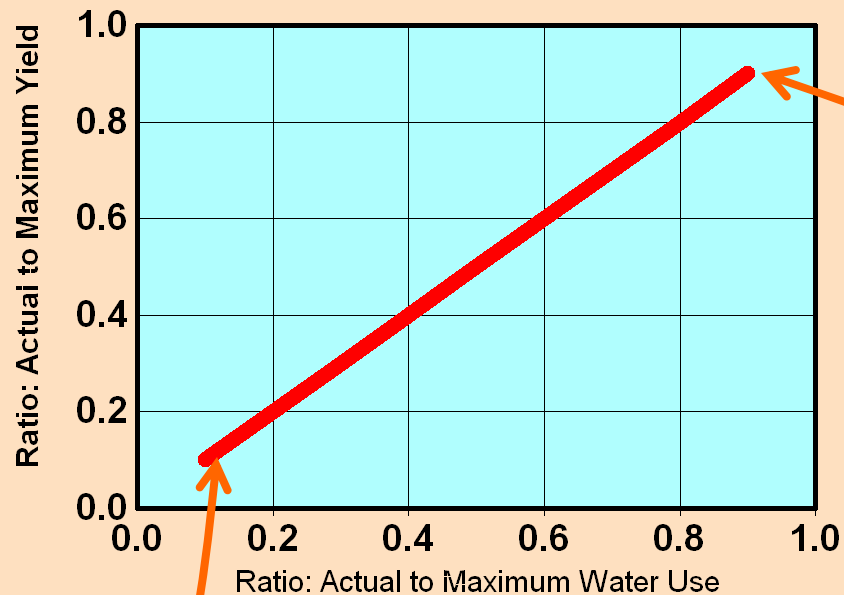
Salts Accumulate

Mild Deficits: Drainage Slows/Stops

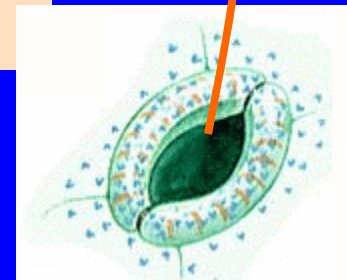
Larger Deficits: Drainage Stops, Reduced ET/Turf Performance

DEFICIT IRRIGATION REDUCES GROWTH

GROWTH vs. WATER USE
Grasses & Forages

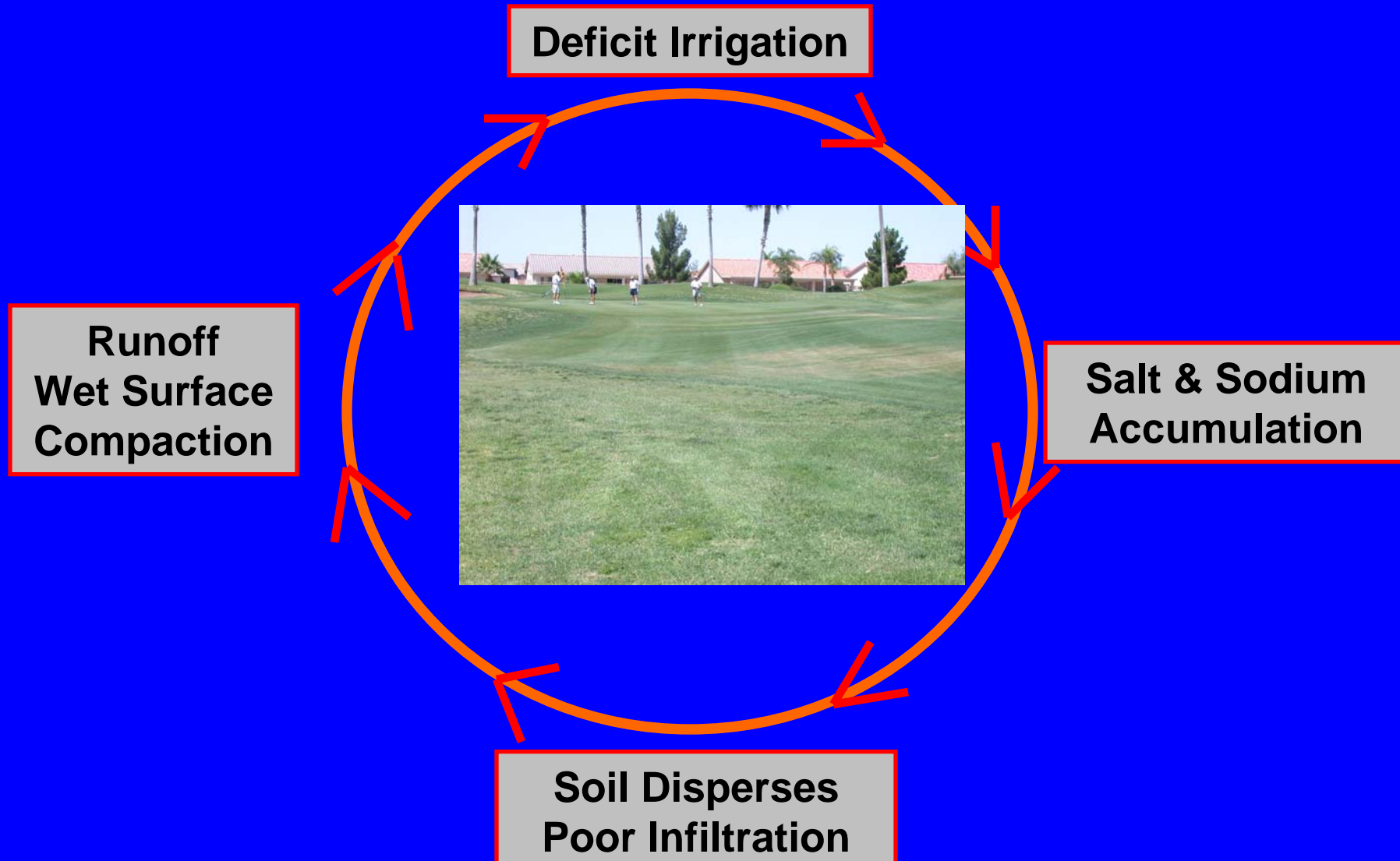


Stomata Closed



Stomata Open

A VICIOUS CIRCLE??

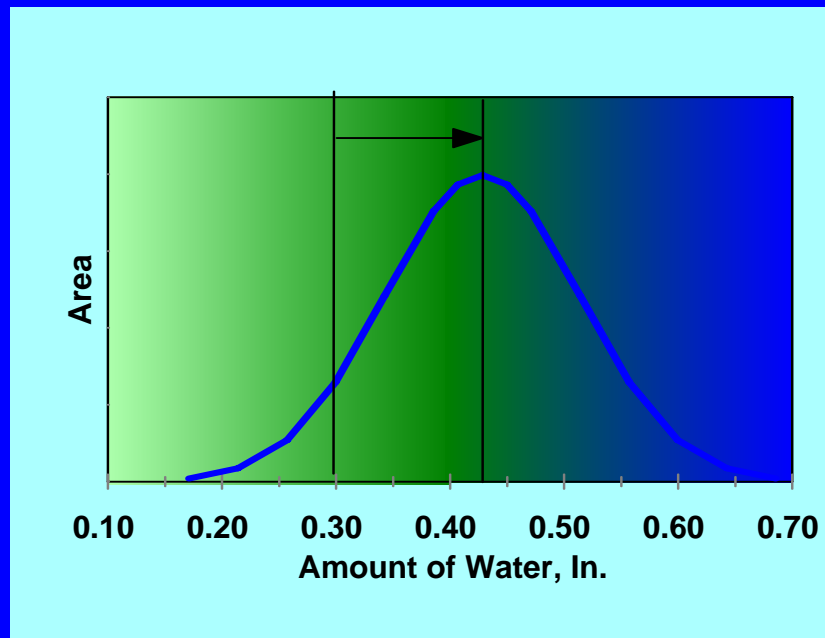


HOW DO WE EFFECTIVELY LEACH THE ENTIRE TURF AREA?

With Non-Uniformity, Playability & Water Supply Concerns...

- **Overseeding**
 - **Purposely Kept Wet for Germination**
- **Periods of Excessive Rainfall**
 - **Especially in Winter**

OVERSEED ESTABLISHMENT



Water TDS ppm	Leaching, % of CU		Leaching, Inches	
	Bermuda	Ryegrass	Bermuda	Ryegrass
100	0.4	0.6	0.27	0.33
250	1.1	1.4	0.68	0.85
400	1.8	2.3	1.11	1.38
550	2.6	3.2	1.55	1.93
700	3.3	4.2	2.00	2.50
850	4.1	5.2	2.46	3.09
1000	4.9	6.2	2.94	3.70
1150	5.7	7.2	3.43	4.34
1300	6.6	8.3	3.93	5.00
1450	7.4	9.5	4.46	5.69
1600	8.3	10.7	4.99	6.40
1750	9.2	11.9	5.55	7.14
1900	10.2	13.2	6.12	7.92
2050	11.2	14.5	6.71	8.72
2200	12.2	15.9	7.32	9.57
2350	13.3	17.4	7.95	10.44
2500	14.3	18.9	8.61	11.36

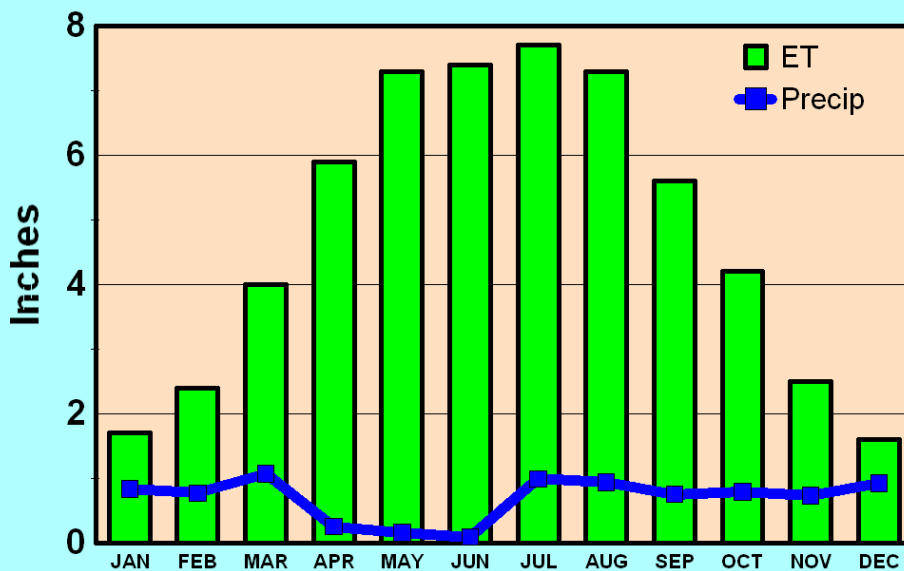
We Purposely Over Water To Ensure Dry Spots Will Support Germination

Leaching Required: 2-5"

WINTER IS BEST TIME TO LEACH

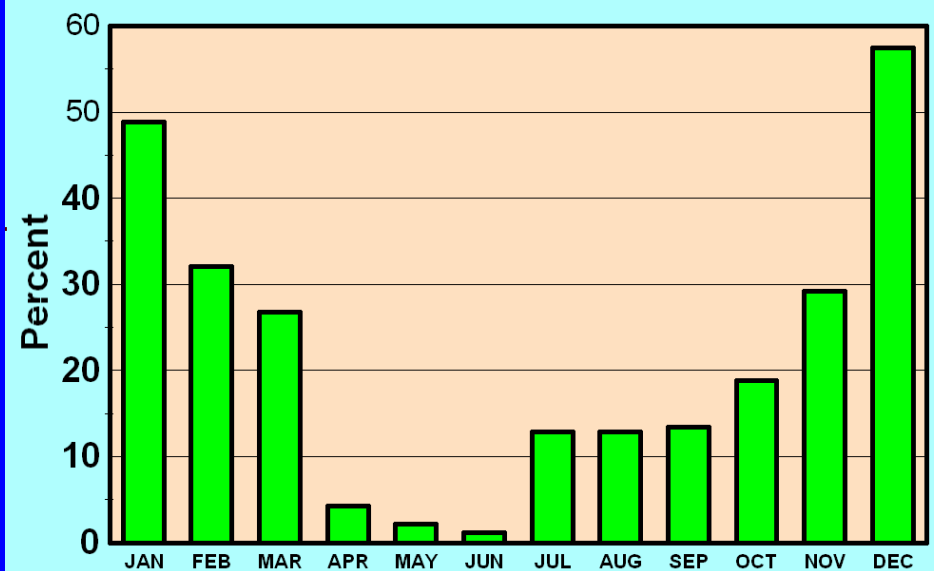
ET is Low & Precipitation Higher

Turf Water Use & Precipitation Phoenix



Precipitation Rarely Exceeds ET Over
Periods in Excess of a Week

Precipitation: % of ET Phoenix



Precipitation ~50% of ET in Winter

WINTER IS THE WORST TIME TO LEACH

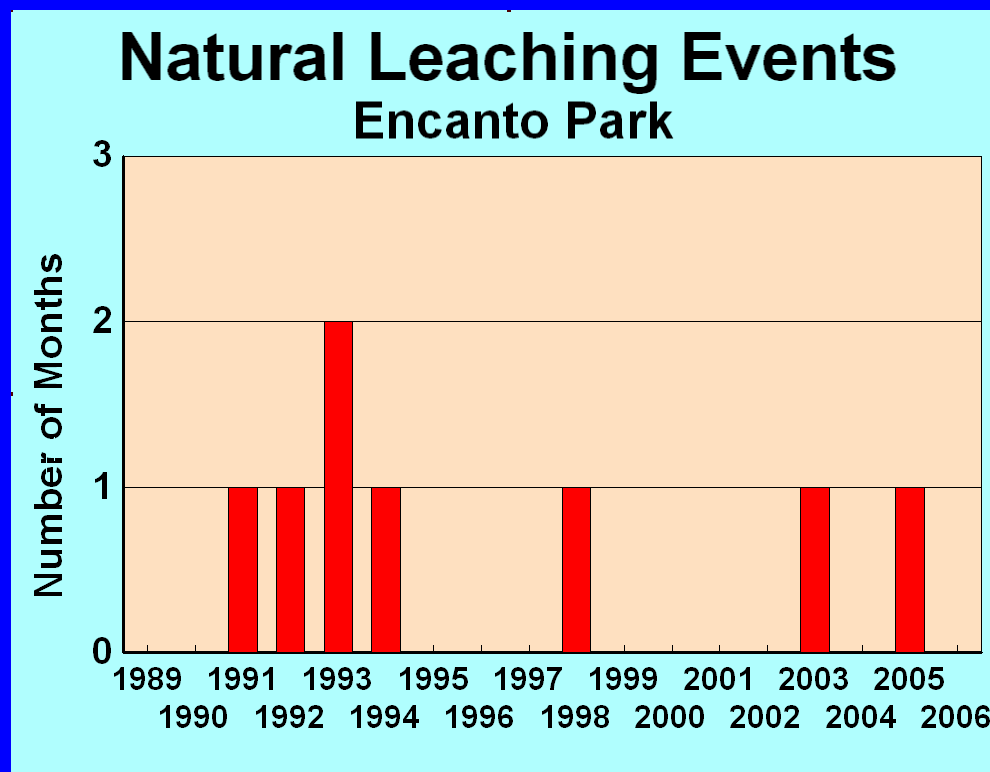
Golf: High Demand, High Greens Fees



**Rainfall Events Reduce Rounds Played & Courses Won't Add
Additional Water To Leach At This Time of Year**

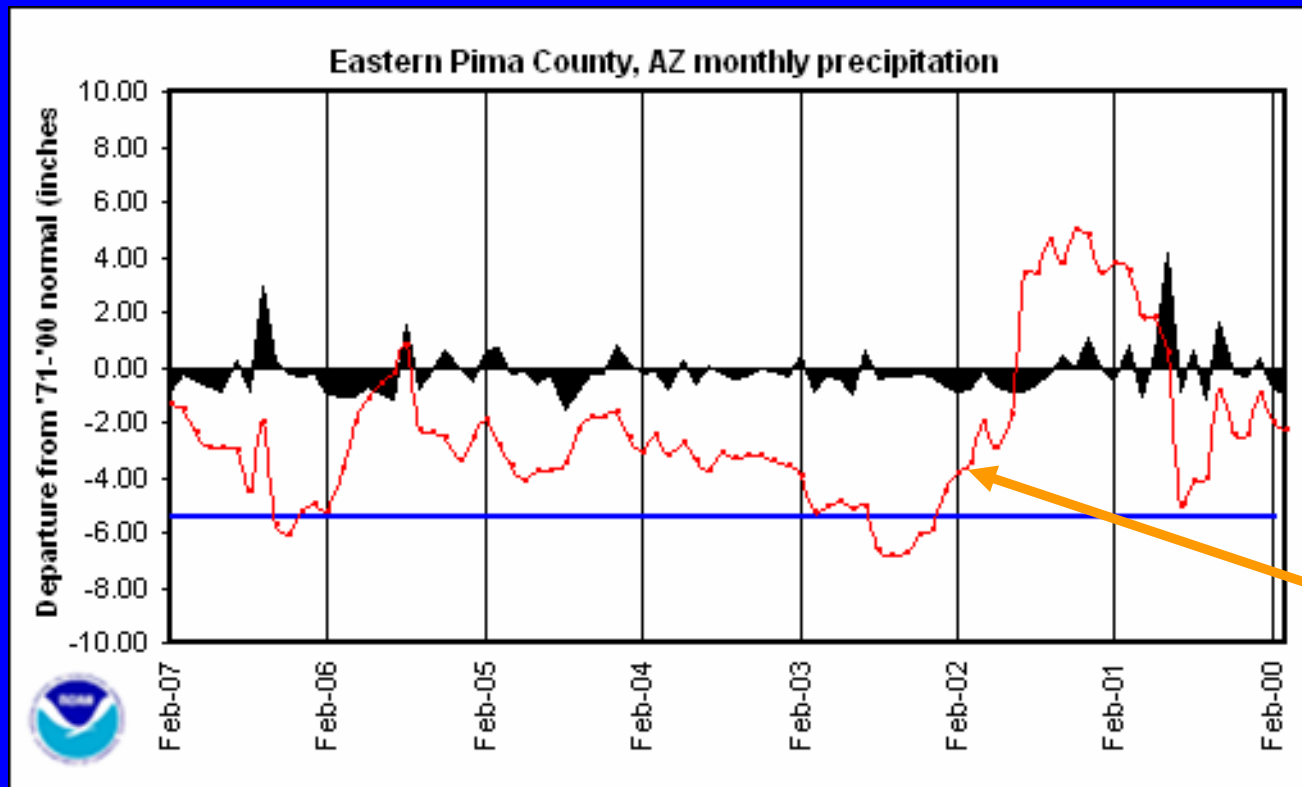
NATURAL LEACHING EVENTS

Monthly Periods When Precipitation Exceeds ETo



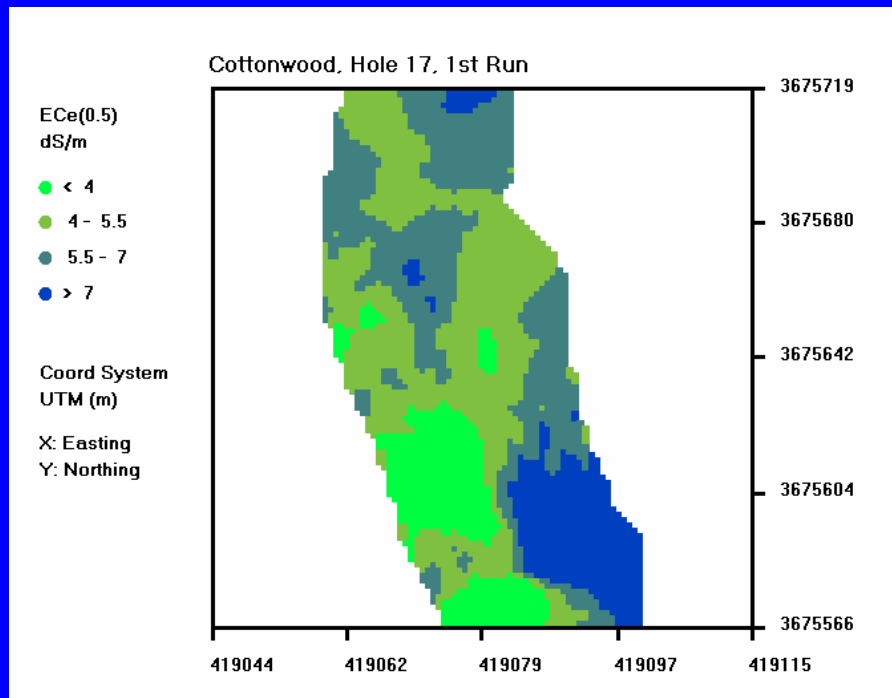
Note: 6 During The 1990s; Just 2 This Decade

DROUGHT & LEACHING

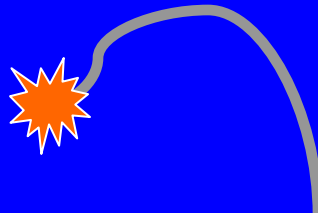


Chronic Drought Has Reduced Winter Precipitation & Lessened the Number of Natural Leaching Events

SALINITY IS ALREADY A PROBLEM



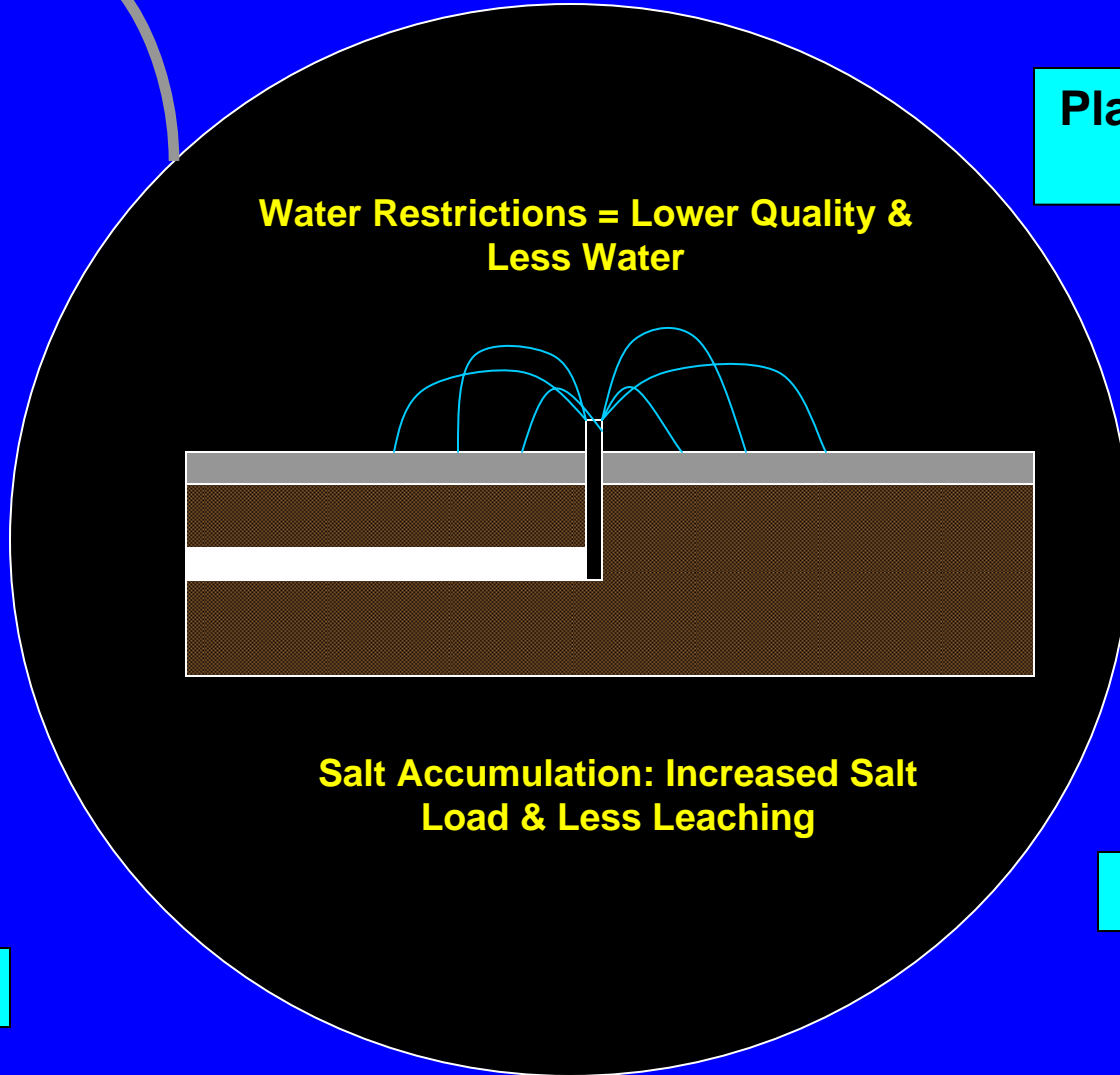
THE SALINITY TIMEBOMB



Water Quantity

**Playability/Deficit
Irrigation**

**Water Restrictions = Lower Quality &
Less Water**



**Salt Accumulation: Increased Salt
Load & Less Leaching**

Drought

Water Quality

SALINITY MANAGEMENT:

LOOKING TO THE FUTURE

- **Understand/Monitor Your Water Supply**
 - **Both Quantity & Quality**
- **Know & Improve Irrigation System**
 - **Precipitation Rates & Uniformiy**
- **Know Your Water Use Rates**
 - **ET & Weather Stations**

SALINITY MANAGEMENT:

LOOKING TO THE FUTURE

- **Maintain Good Surface Soil Structure**
 - **Chemical & Physical Means**
- **Leach Your Turf**
 - **Overseeding & Wet Winter Periods**
 - **Closing Course 1 Day/Week?**
- **Improve Turf Salinity Tolerance**

THANK YOU

EMAIL: PBROWN@AG.ARIZONA.EDU